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CLAIMS

1. A fuel injection control apparatus for an
internal combustion engine equipped with a fuel injection
valve for directly injecting high pressure fuel supplied
by high pressure fuel supply means into a cylinder,
comprising:

in-cylinder pressure detection means for detecting
or estimating in-cylinder pressure of said cylinder;

time period calculation means for calculating fuel
injection time period over which fuel is injected from
said fuel injection valve, the fuel injection time period
being corrected to compensate a variation in the fuel
injection quantity caused by a variation in the fuel
injection rate due to a variation in the in-cylinder
pressure detected or estimated by said in-cylinder
pressure detection means relative to a reference in-
cylinder pressure that is stored in advance;

start time variation calculation means for
calculating a variation in the fuel injection start time
at the in-cylinder pressure detected or estimated by said
in-cylinder pressure detection means relative to the fuel
injection start time at said reference in-cylinder
pressure;

control means for controlling the time period over
which fuel is injected from said fuel injection valve
based on the fuel injection time period calculated by said

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time period calculation means and the variation in the
fuel injection start time calculated by said start time
variation calculation means.

2. A fuel injection control apparatus for an
internal combustion engine according to claim 1, further
comprising:

fuel pressure detection means for detecting the
pressure of the high pressure fuel supplied to said fuel
injection valve by said high pressure fuel supply means;

fuel injection quantity characteristic storing means
for storing a characteristic, in relation to valve opening
time of said fuel injection valve, of the fuel injection
quantity injected by said fuel injection valve during the
valve opening time in accordance with the pressure of the
high pressure fuel supplied to said fuel injection valve
by said high pressure fuel supply means;

required fuel injection quantity calculation means
for calculating a desired fuel injection quantity based on
the running state of the internal combustion engine;

fuel injection rate calculation means for
calculating fuel injection rate based on the fuel pressure
detected by said fuel pressure detection means and the in-
cylinder pressure detected or estimated by said in-
cylinder pressure detection means;

fuel injection quantity variation calculation means
for calculating a variation in the fuel injection quantity

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caused by a variation in a second fuel injection rate
calculated by said fuel injection rate calculation means
based on the in-cylinder pressure detected or estimated by
said in-cylinder pressure detection means relative to a

5   first fuel injection rate calculated by said fuel
injection rate calculation means based on said reference
in-cylinder pressure;

coefficient calculation means for calculating a
variation in fuel injection delay time per unit in-

10   cylinder pressure for the fuel pressure detected by said
fuel pressure detection means,

wherein, said time period calculation means
calculates the fuel injection time period utilizing said
fuel injection quantity characteristic storing means based

15   on the variation in the fuel injection quantity calculated
by said fuel injection quantity variation calculation
means and the fuel injection quantity calculated by said
required fuel injection quantity calculation means,

said start time variation calculation means

20   calculates the variation in the fuel injection start time
based on a variation in the in-cylinder pressure detected
or estimated by said in-cylinder pressure detection means
relative to said reference in-cylinder pressure and the
variation calculated by said coefficient calculation means.

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3. A fuel injection control apparatus for an
internal combustion engine according to claim 2, further

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comprising:

a needle valve provided in said fuel injection valve that moves in the axial direction to effect valve opening and closing operations;

5   fuel injection quantity estimation means for estimating, when fuel injection by said fuel injection valve is started, the quantity of fuel injected since the valve opening operation of said needle valve is started until said needle valve reaches a full open state, based

10   on the fuel pressure detected by said fuel pressure detection means and the in-cylinder pressure detected or estimated by said in-cylinder pressure detection means;

comparison means for comparing the estimated fuel quantity estimated by said fuel injection quantity

15   estimation means and the fuel injection quantity calculated by said required fuel injection quantity calculation means,

wherein, said fuel injection quantity variation calculation means calculates the variation in the fuel

20   injection quantity using different calculation processes, in accordance with a result of the comparison by said comparison means, between in the case that said fuel injection quantity is less than said estimated fuel quantity and in the case that said fuel injection quantity

25   is more than or equal to said estimated fuel quantity.

4. A fuel injection control apparatus for an

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internal combustion engine according to claim 2 or 3,
wherein said fuel injection quantity variation calculation
means calculates the variation in the fuel injection
quantity by modeling a change with time in the fuel
5   injection rate as a polygon in a coordinate system and
calculating a change in the area of said polygon.

5. A fuel injection control apparatus for an
internal combustion engine according to claim 3, wherein
10   said fuel injection quantity variation calculation means
further comprises:
suction chamber pressure calculation means for
calculating pressure in a suction chamber formed in the
tip end side of a valve seat on/from which said needle
15   valve is to be received/detached, based on the fuel
pressure detected by said fuel pressure detection means
and the position of said needle valve;
unit fuel injection quantity variation calculation
means for calculating a variation in the fuel injection
20   quantity per unit in-cylinder pressure based on the fuel
injection quantity calculated by said required fuel
injection quantity calculation means and the suction
chamber pressure calculated by said suction chamber
pressure calculation means,
25   wherein, when according to a result of the
comparison by said comparison means, said fuel injection
quantity is less than said estimated fuel injection

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quantity, said fuel injection quantity variation

calculation means calculates the variation in the fuel

injection quantity based on a variation in the in-cylinder

pressure detected or estimated by said in-cylinder

5   pressure detection means relative to said reference in-

cylinder pressure and the variation in the fuel injection

quantity per unit in-cylinder pressure calculated by said

unit fuel injection quantity variation calculation means.

10   6. A fuel injection control apparatus for an

internal combustion engine according to claim 1, further

comprising:

        fuel pressure detection means for detecting the

pressure of the high pressure fuel supplied to said fuel

15   injection valve by said high pressure fuel supply means;

        fuel injection quantity characteristic storing means

for storing a characteristic, in relation to valve opening

time of said fuel injection valve, of the fuel injection

quantity injected by said fuel injection valve during the

20   valve opening time in accordance with the pressure of the

high pressure fuel supplied to said fuel injection valve

by said high pressure fuel supply means;

        required fuel injection quantity calculation means

for calculating a desired fuel injection quantity based on

25   the running state of the internal combustion engine;

        first virtual fuel pressure calculation means for

calculating a first virtual fuel pressure by subtracting a

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variation in the in-cylinder pressure detected or

estimated by said in-cylinder pressure detection means

relative to said reference in-cylinder pressure from the

fuel pressure detected by said fuel pressure detection

5   means;

         second virtual fuel pressure calculation means for

calculating a second virtual fuel pressure by adding a

variation in the in-cylinder pressure detected or

estimated by said in-cylinder pressure detection means

10   relative to said reference in-cylinder pressure to the

fuel pressure detected by said fuel pressure detection

means;

         injection delay time calculation means for

calculating injection delay time from the time at which a

15   signal for opening said fuel injection valve is generated

to the time at which fuel injection by said fuel injection

valve is started, based on the fuel pressure detected by

said fuel pressure detection means,

         wherein, said time period calculation means

20   calculates the fuel injection time period utilizing said

fuel injection characteristic storing means based on the

first virtual fuel pressure calculated by said first

virtual fuel pressure calculation means and the fuel

injection quantity calculated by said required fuel

25   injection quantity calculation means, and

         said start time variation calculation means

calculates, by means of said fuel injection delay time

calculation means, a fuel injection delay time for the fuel pressure detected by said fuel pressure detection means and a fuel injection delay time for the second virtual fuel pressure calculated by said second virtual

5   fuel pressure calculation means and calculates the variation in the fuel injection start time from a difference between those injection delay times.

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